

WHAT IS CLAIMED IS:

1                   1.       A method for forming a trench having rounded corners in a  
2 semiconductor device, the method comprising:  
3                   providing a semiconductor substrate;  
4                   forming a first pad oxide layer, a first silicon nitride layer, and a first oxide  
5 layer on the semiconductor substrate sequentially;  
6                   removing portions of the first oxide layer, the first silicon nitride layer, the  
7 first pad oxide layer, and the semiconductor substrate to form at least one trench;  
8                   removing portions of the first oxide layer, the first silicon nitride layer, and  
9 the first pad oxide layer in the trench above an upper corner of the semiconductor substrate  
10 in the trench, the semiconductor substrate including a lower corner at a bottom of the  
11 trench;  
12                  forming a second pad oxide layer in the trench;  
13                  forming a second silicon nitride layer on the second pad oxide layer and the  
14 first oxide layer;  
15                  removing portions of the second silicon nitride layer to expose the second  
16 pad oxide layer on the corners and the bottom of the trench;  
17                  forming a thermal oxide layer on the second pad oxide layer exposed by  
18 removing the portions of the second nitride layer; and  
19                  removing the second silicon nitride layer, the thermal oxide layer, and the  
20 second pad oxide layer.

1                   2.       The method of claim 1 wherein removing portions of the first oxide  
2 layer, the first silicon nitride layer, the first oxide layer, and the semiconductor substrate is  
3 performed by a photolithography process or an etching process.

1                   3.       The method of claim 1 wherein the at least one trench has a depth of  
2 between about 1 $\mu$ m and about 3 $\mu$ m and a width of about 0.2 $\mu$ m and about 1 $\mu$ m.

1                   4.       The method of claim 1 wherein removing portions of the first oxide  
2 layer, the first silicon nitride layer, and the first pad oxide layer in the trench is performed  
3 using HF.

1                   5.       The method of claim 1 wherein the second silicon nitride layer is  
2 formed by deposition.

1                   6.       The method of claim 1 wherein removing portions of the second  
2 silicon nitride layer to expose the second pad oxide layer is performed by dry etching.

1                   7.       The method of claim 1 wherein the thermal oxide layer is formed by  
2 thermal oxidation.

1                   8.       The method of claim 1 wherein removing the second nitride layer,  
2 the thermal oxide layer, and the second pad oxide layer is performed with phosphoric acid.

1                   9.       The method of claim 1 further comprising forming a second oxide  
2 layer in the trench and on the first oxide layer after removing the second silicon nitride  
3 layer, the thermal oxide layer, and the second pad oxide layer.

1                   10.      The method of claim 1 wherein the second pad oxide layer is  
2 formed over surfaces of the semiconductor substrate in the trench.

1                   11.      The method of claim 1 wherein removing portions of the first oxide  
2 layer, the first silicon nitride layer, and the first pad oxide layer in the trench exposes the  
3 upper corner of the semiconductor substrate in the trench.

1                   12.      The method of claim 1 wherein removing the second silicon nitride  
2 layer, the thermal oxide layer, and the second pad oxide layer forms a rounded upper  
3 corner and a rounded lower corner of the semiconductor substrate in the trench for a  
4 trench-type metal oxide semiconductor device.

1                   13.      A method for forming a trench having rounded corners in a  
2 semiconductor device, the method comprising:  
3                   providing a semiconductor substrate having thereon a first pad oxide layer,  
4 a first silicon nitride layer on the first pad oxide layer, and a first oxide layer on the first  
5 silicon nitride layer, and at least one trench extending through the first oxide layer, the first  
6 silicon nitride layer, and the first pad oxide layer, and partially through the semiconductor  
7 substrate; wherein the trench is enlarged above the semiconductor substrate along  
8 sidewalls of the first oxide layer, the first silicon nitride layer, and the first pad oxide  
9 layer; wherein the semiconductor substrate includes a lower corner at a bottom of the  
10 trench and an upper corner below the sidewalls of the first oxide layer, the first silicon  
11 nitride layer, and the first pad oxide layer;

12 forming a second pad oxide layer in the trench;  
13 forming a second silicon nitride layer on the second pad oxide layer and the  
14 first oxide layer;  
15 removing portions of the second silicon nitride layer to expose the second  
16 pad oxide layer on the corners and the bottom of the trench;  
17 forming a thermal oxide layer on the second pad oxide layer exposed by  
18 removing the portions of the second nitride layer; and  
19 removing the second silicon nitride layer, the thermal oxide layer and the  
20 second pad oxide layer.

1 14. The method of claim 13 further comprising forming a second oxide  
2 layer in the trench and on the first oxide layer after removing the second silicon nitride  
3 layer, the thermal oxide layer, and the second pad oxide layer.

1 15. The method of claim 13 wherein the second pad oxide layer is  
2 formed over surfaces of the semiconductor substrate in the trench.

1 16. The method of claim 13 wherein removing portions of the first  
2 oxide layer, the first silicon nitride layer, and the first pad oxide layer in the trench  
3 exposes the upper corner of the semiconductor substrate in the trench.

1 17. The method of claim 13 wherein removing the second silicon  
2 nitride layer, the thermal oxide layer, and the second pad oxide layer forms a rounded  
3 upper corner and a rounded lower corner of the semiconductor substrate in the trench.

1 18. A method for forming a trench having rounded corners in a  
2 semiconductor device, the method comprising:  
3 providing a semiconductor substrate having thereon a first pad oxide layer,  
4 a first silicon nitride layer on the first pad oxide layer, and a first oxide layer on the first  
5 silicon nitride layer, and at least one trench extending through the first oxide layer, the first  
6 silicon nitride layer, and the first pad oxide layer, and partially through the semiconductor  
7 substrate; wherein the trench is enlarged above the semiconductor substrate along  
8 sidewalls of the first oxide layer, the first silicon nitride layer, and the first pad oxide  
9 layer; wherein the semiconductor substrate includes a lower corner at a bottom of the  
10 trench and an upper corner below the sidewalls of the first oxide layer, the first silicon  
11 nitride layer, and the first pad oxide layer; wherein a second pad oxide layer is formed in

12 the trench and a second silicon nitride layer is formed on the second pad oxide layer and  
13 the first oxide layer;  
14 removing portions of the second silicon nitride layer to expose the second  
15 pad oxide layer on the corners and the bottom of the trench;  
16 forming a thermal oxide layer on the second pad oxide layer exposed by  
17 removing the portions of the second nitride layer; and  
18 removing the second silicon nitride layer, the thermal oxide layer and the  
19 second pad oxide layer.

1 19. The method of claim 18 wherein removing portions of the first  
2 oxide layer, the first silicon nitride layer, and the first pad oxide layer in the trench  
3 exposes the upper corner of the semiconductor substrate in the trench; and wherein the  
4 second pad oxide layer is formed over surfaces of the semiconductor substrate in the  
5 trench.

1 20. The method of claim 18 wherein removing the second silicon  
2 nitride layer, the thermal oxide layer, and the second pad oxide layer forms a rounded  
3 upper corner and a rounded lower corner of the semiconductor substrate in the trench for a  
4 trench-type metal oxide semiconductor device.